

Natural Gas Forecasts Using GPCM® for IEPR
2007 Scenario Analysis Project: Results and
Methodology

Ann T. Donnelly, Ph.D.
August 16, 2007

Global Energy Decisions

Natural Gas Forecast Study Group December 2006 – July 2007

Global Energy
incorporated a
collaborative process
with Commission staff
and Aspen and R.W.
Beck consultants

Global Energy Decisions was responsible for producing the forecasts

- Ann Donnelly (Project Manager)
- Gurinder Goel (GPCM Modeler)
- Mike Donnelly
- Rich Lauckhart
- Andy Wetz
- Brian Swann

Commission staff supervised and participated in the work

- Ruben Tavares
- Mike Jaske
- Dave Ashukian
- Mike Purcell
- Lana Wong
- Leon Brathwait

Aspen and R.W. Beck staff also played review/advisory roles

- Bob Logan
- Katie Elder
- Youssef Hegazy
- Carl Linvill

The full results of our study are incorporated in Appendices H-1 through H-6 to the Commission Report on the 2007 IEPR Scenario Analysis Project

Topics Today

Executive summary of the forecast results (5 minutes)

How are stochastic forecasts done? (5 minutes)

The basics of the GPCM® (10 minutes)

Integration of the gas forecasts with the MarketSym™ runs of the IEPR Scenarios (10 minutes)

Methodology and Results of Eight Forecasts (25 minutes)

Limitations of the Analysis and Next Steps (5 Minutes)

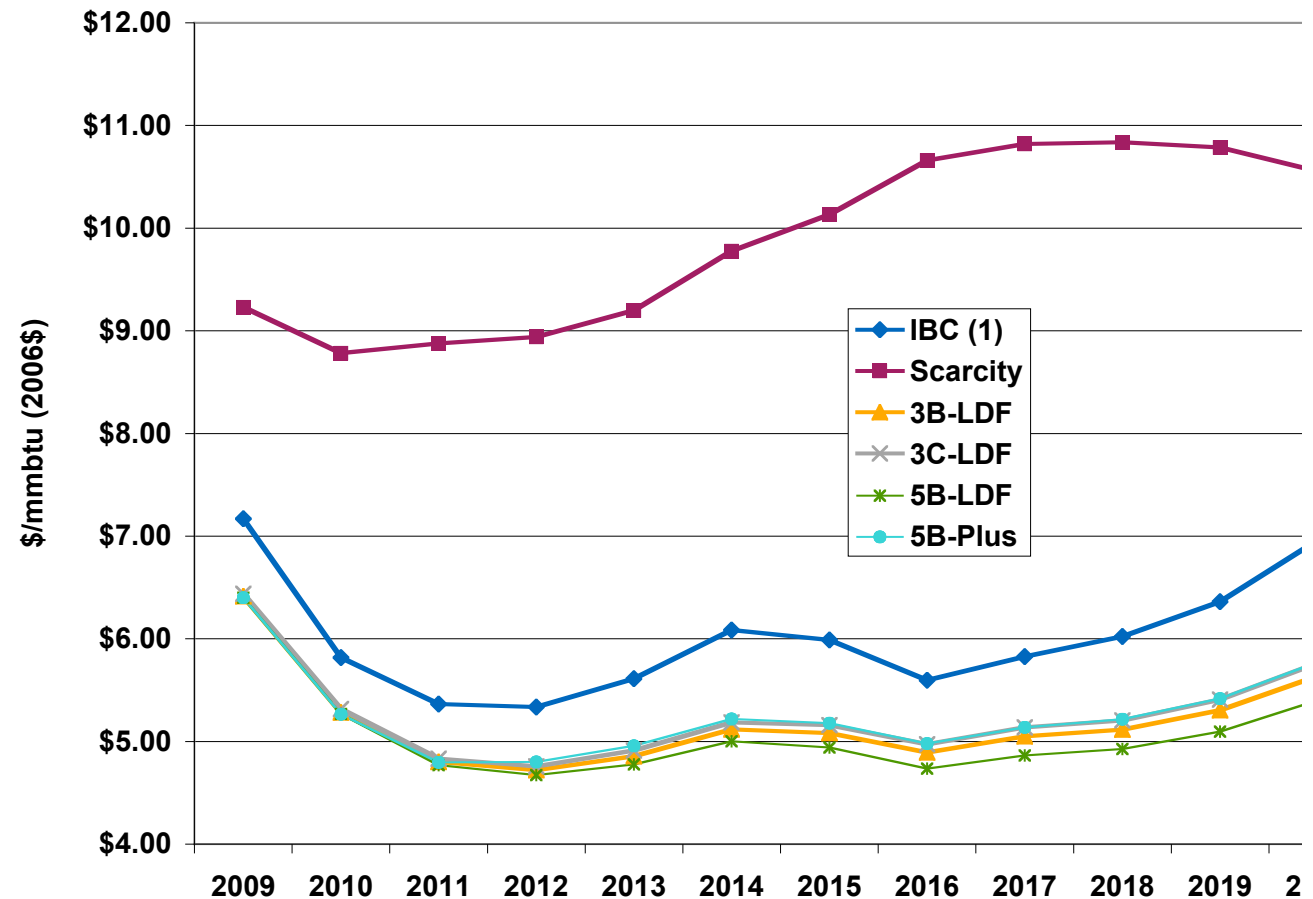
Executive Summary of the Henry Hub Forecast Results

Low-Demand Forecasts (2006\$/MMBtu)⁽¹⁾ Compared to IBC Scarcity Forecasts

An Illustrative Base Case (IBC) and five scenarios were run. The five scenarios included a Gas Scarcity Case and four Low-Demand cases.

The scarcity prices are approximately \$4-\$5/MMBtu higher than the Base Case.

The Low Demand Cases are approximately \$0.50-\$1.00/MMBtu lower than the Base Case.



- 1) For Henry Hub forecast GED uses NYMEX for the first 24 months and then mean reverts for following 24 months to our fundamental forecast. For IBC forecast start in 2007 for NYMEX an average of the latest available three days were used (i.e. Dec 19-21 2006).

Results of the Forecasts Henry Hub Prices (2006\$/MMBtu)

LDF = Low Demand
Forecast

IBC = “Illustrative Base
Case” or simply “Base
Case”

The Base Case
consisted of Global
Energy’s December
2006 Reference Case
modified in only one
way – the insertion of
EIA’s AEO 2007 crude
oil forecast.

\$/mmbtu (2006\$)	IBC (1)	Scarcity	3B-LDF	3C- LDF	5B- LDF	5C- LDF
2009	\$7.17	\$9.23	\$6.42	\$6.44	\$6.40	\$6.40
2010	\$5.82	\$8.78	\$5.28	\$5.32	\$5.27	\$5.27
2011	\$5.36	\$8.88	\$4.80	\$4.83	\$4.77	\$4.77
2012	\$5.34	\$8.94	\$4.72	\$4.76	\$4.67	\$4.67
2013	\$5.61	\$9.20	\$4.86	\$4.91	\$4.78	\$4.78
2014	\$6.09	\$9.78	\$5.12	\$5.19	\$5.00	\$5.00
2015	\$5.99	\$10.13	\$5.08	\$5.16	\$4.94	\$4.94
2016	\$5.60	\$10.66	\$4.89	\$4.97	\$4.73	\$4.73
2017	\$5.83	\$10.82	\$5.05	\$5.14	\$4.86	\$4.86
2018	\$6.02	\$10.84	\$5.11	\$5.21	\$4.93	\$4.93
2019	\$6.36	\$10.78	\$5.30	\$5.41	\$5.10	\$5.10
2020	\$6.96	\$10.55	\$5.64	\$5.76	\$5.40	\$5.40
2011-2020 Average	\$5.92	\$9.88	\$5.06	\$5.26	\$4.92	\$4.92

Results continued,
The Stochastic Forecasts
(Henry Hub) (2006 \$/MMBtu)

Stochastic forecasts are purely mathematical results of Monte Carlo analysis. They do not represent different scenarios with different input assumptions.

We produced the stochastic forecast around our Base Case (P50). The P25 (Low Case) and P75 (High Case) were used for this project.

Data Period	Base Case P50	Base Case P75	Base Case P25
2009	7.17	8.66	5.36
2010	5.82	7.42	4.29
2011	5.36	6.47	3.66
2012	5.34	6.48	3.61
2013	5.61	6.98	3.63
2014	6.09	7.56	3.85
2015	5.99	7.35	3.81
2016	5.60	6.99	3.45
2017	5.83	7.24	3.56
2018	6.02	7.54	3.57
2019	6.36	7.91	3.79
2020	6.96	8.60	4.12

Appendix H-4 describes this process in detail.

Global Energy constantly updates our volatility history and analysis, which is key to both the mean reversion (MR) process and the daily volatilities.

We use a simple time series, e.g. use last two years of history for next two years of volatility and MR estimates; 4 years for 3-4 years, etc.

How Are the Stochastic Forecasts Done?

The stochastic forecasts simulate the probabilistic results of a wide variety of shocks of various magnitudes such as:

- Hurricane event
- Pipeline rupture
- Co-occurrence of several factors, such as slack demand combined with pipeline maintenance event

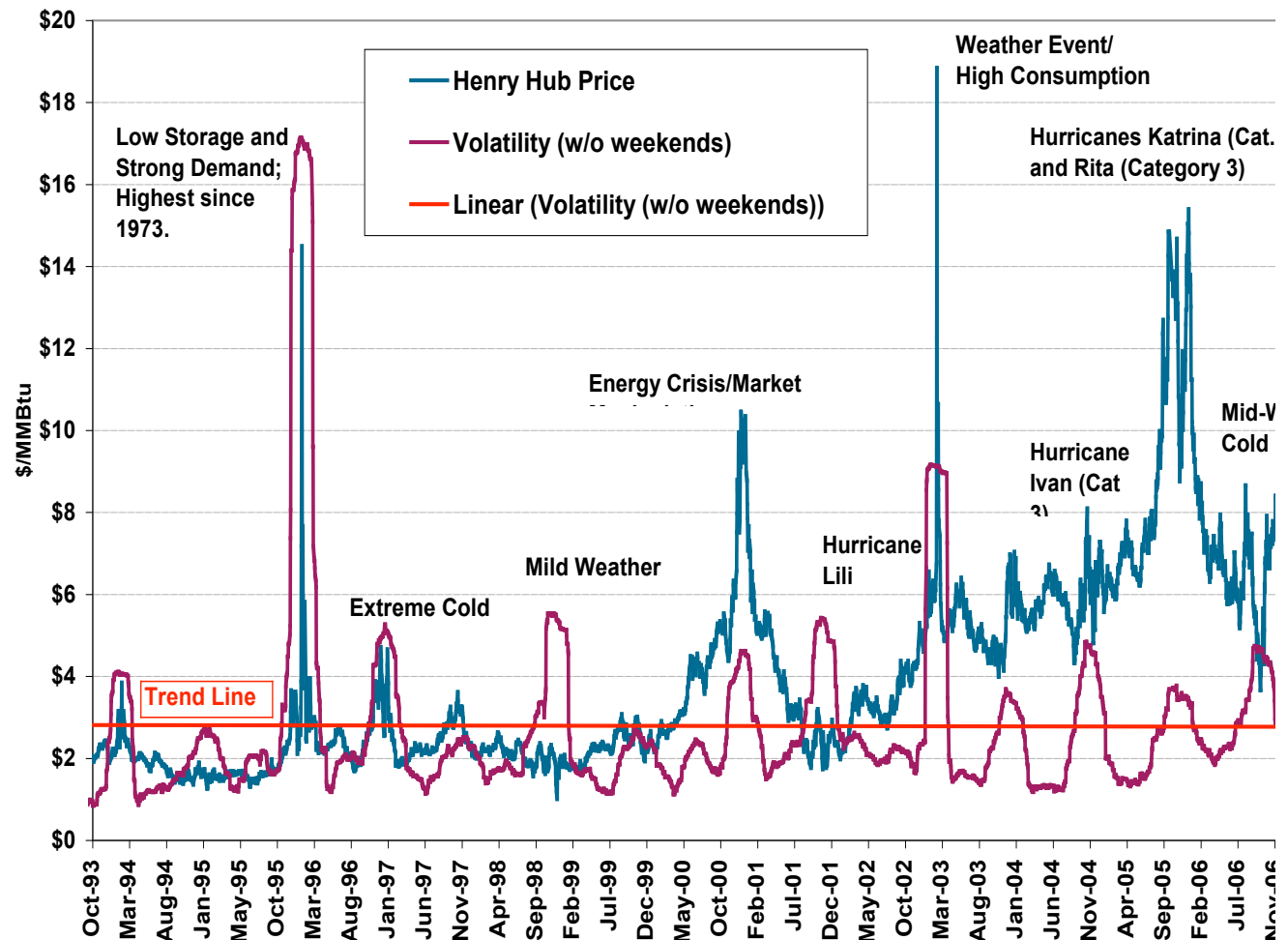
We use Global Energy's Planning and Risk TM software:

- Step 1: start with GPCM Henry Hub Price (monthly)
- Step 2: Perform daily stochastic draws based on daily volatilities and mean reversion parameters from historical data
- Step 3: For the end of each month, average daily prices for 500 iterations
- Step 4: Sort the average prices from highest to lowest
- Step 5: The iteration that is 25% from the top is P75 and the iteration that is 75% from the top is P25, etc.

Has Gas Price Volatility Increased in Recent Years?

Despite news headlines, the volatility of gas prices has not increased in recent years. It has been and remains high compared to many commodities.

Volatility history is not a perfect tool to predict the future of volatility! However, it is the best available source of quantitative analysis.



Volatilities shown are 90-day volatilities. Shorter terms would give spikier traces. Units of volatility are percentage per day for one standard deviation. Gas prices are nominal \$/MMBtu.

Global Energy's experience has been that the leading gas market simulation models in use in North America have many principles and features in common, but also differences – some of an “accounting” nature - that make direct comparison of their detailed results a challenge

The Basics of GPCM®

Fundamental Principles, Inputs and Outputs

Global Energy licenses GPCM® from RBAC, Inc. (www.rbac.com) to produce our Natural Gas Reference Case for North America

The fundamental principles of GPCM® are:

- Markets are competitive.
- Prices will rise or fall to clear the markets.
- Gas will flow from production to consumption regions so as to minimize transportation and storage costs while clearing markets
- The resulting set of flows constitutes an “economic equilibrium” for the natural gas industry

GPCM®'s supply model includes 107 existing and potential supply sources to the North American gas system:

- 55 U.S. production areas including Alaska
- 13 Canadian production areas including Newfoundland CNG plant
- 68 Subtotal indigenous sources
- 37 existing and potential LNG regasification plants in the U.S., Canada, Mexico, Bahamas
- 2 Mexico production (conventional) sources
- 107 Total

In GPCM, Alaska North Slope Gas is accounted for as an import into Canada; some of its volume is used to satisfy Canadian demand, with the remainder accounted for as an export to the U.S. Lower 48.

Virtually all of the features of GPCM are transparent to the licensee and have been available to the CEC study group for review.

Global Energy has provided the CEC study group with workshops/webinars on the GPCM Upstream Model, how volume and price are interrelated in GPCM and other details of GPCM methodology

GPCM Inputs and Outputs

Data inputs for GPCM® are updated quarterly:

- Tables representing the basic entities of the model (suppliers, supply regions, customers, demand regions, pipeline zones, storage facilities),
- Tables relating these entities representing the structural linkages in the model
- The quantitative data representing supplies (such as U.S. production, Canadian imports, LNG), demands (electricity, industrial, and residential/commercial), tariffs, pipeline and interconnect capacities, fuel use, and other parameters.
- Crude oil forecast and crude oil price to gas price ratio.

The output of GPCM® consists of forecasts of natural gas industry activity, including the following types:

- Production and spot market prices by supply region
- Pipeline receipts from producers by zone
- Pipeline flows from zone to zone
- Transportation prices and discounting from full tariff by pipeline to generate basis or spread
- Transfers between pipelines at interconnects
- Injections into and withdrawals from storage
- Deliveries by pipelines to customers
- Gas supply available to each customer in each demand region
- Market clearing prices in each region

Description of Gas Supply Methodology for GPCM®

The range of Price/Quantity points (high, median, low) establish three points on the supply availability curves for 70 N.A. supply sources.

Incremental production and its price at the nearest market hub can be derived from this supply curve.

See the next slide.

The model includes sites for more than 30 LNG regasification terminals which are treated as “supply basins”

The proprietary upstream model provides the median production potential for 55 indigenous supply basins in the US, 13 in Canada, and 2 in Mexico.

This output is combined in GPCM with a median price derived by a statistical formula based on the ratios of the average annual prices for the Lower 48 wellhead gas and for West Texas Intermediate oil.

These ratios are applied against the nearest market hub’s prior year price to derive the median price for that hub.

The potential annual price range (low and high) for each supply region is used to derive the potential range (low and high) of the annual quantity of production, and together establish the annual forecast of the price elasticity factors.

GPCM

Volume

Price

Upstream Model Reserves and Production

Supply Basin Area

- Production Decline Curves
- Reserves In-ground
- Reserve Additions
- R/P Ratio

Median Production Potential (QMed)
Used for Supplier Delivery Curves by Supply
Areas

Average Annual Prices
Wellhead gas¹ = [(0.1495)(WTI)] - 0.953
Oil/gas ratio = WTI/Wellhead gas

¹ Lower 48

Median Price for Supply Area (PMed)
Year n = $\left[\frac{W_{\text{gas } n}}{W_{\text{gas } 2005}} \div \left[\frac{\text{oil/gas ratio } n}{\text{oil/gas ratio } 2005} \right] \right] \times 2005 \text{ PMed}$

First Point on Supply (Price) Curve
Q+PMed

Potential Price Range for Supply Area

PLow

~ 50% PMed

PHigh

~ 200% PMed

Potential Production Range (exponential function)

QLow		QHigh	
QMed	$\left[\frac{P_{\text{Low}}}{P_{\text{Med}}} \right]^{E_{\text{Low}}}$	QMed	$\left[\frac{P_{\text{High}}}{P_{\text{Med}}} \right]^{E_{\text{High}}}$

Price Elasticity Factor (Natural Logarithm)

ELow	EHigh
$\ln \frac{Q_{\text{Med}}}{Q_{\text{Low}}} \div \ln \frac{P_{\text{Med}}}{P_{\text{Low}}}$	$\ln \frac{Q_{\text{High}}}{Q_{\text{Med}}} \div \ln \frac{P_{\text{High}}}{P_{\text{Med}}}$

Three Points on Supply Price Curve

Q/PMed
Q/PLow
Q/PHigh

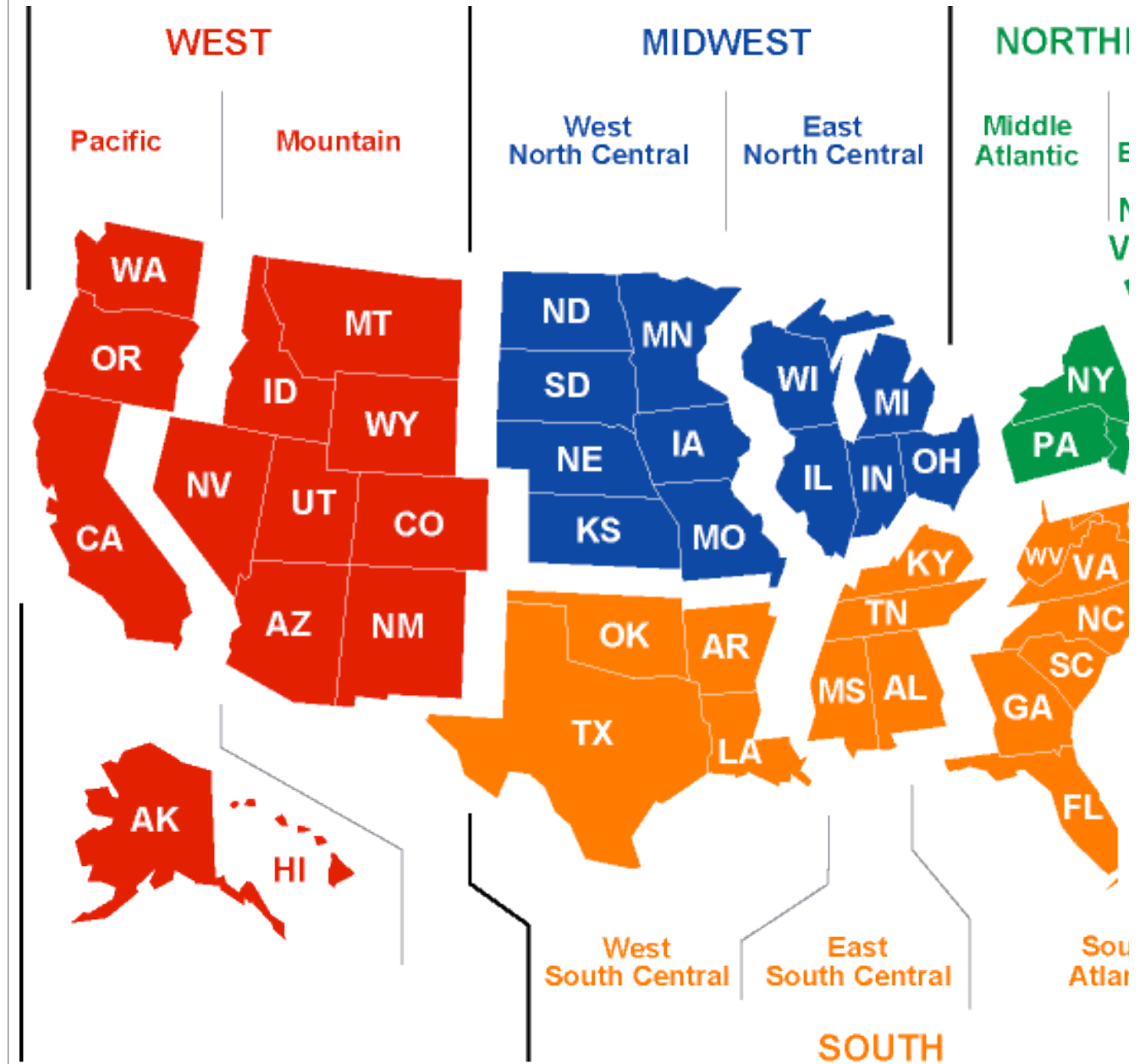
Supplier Price Delivery Curve for 107 Supply Regions

Domestic	Canada	LNG	Mexico
53 Lower 48	13	37	2

U.S. Census Regions and Divisions

GPCM uses U.S. census regions and divisions to aggregate gas consumption data. It can also aggregate the data by state.

Data for producing basins can also be aggregated by state and census regions/divisions.

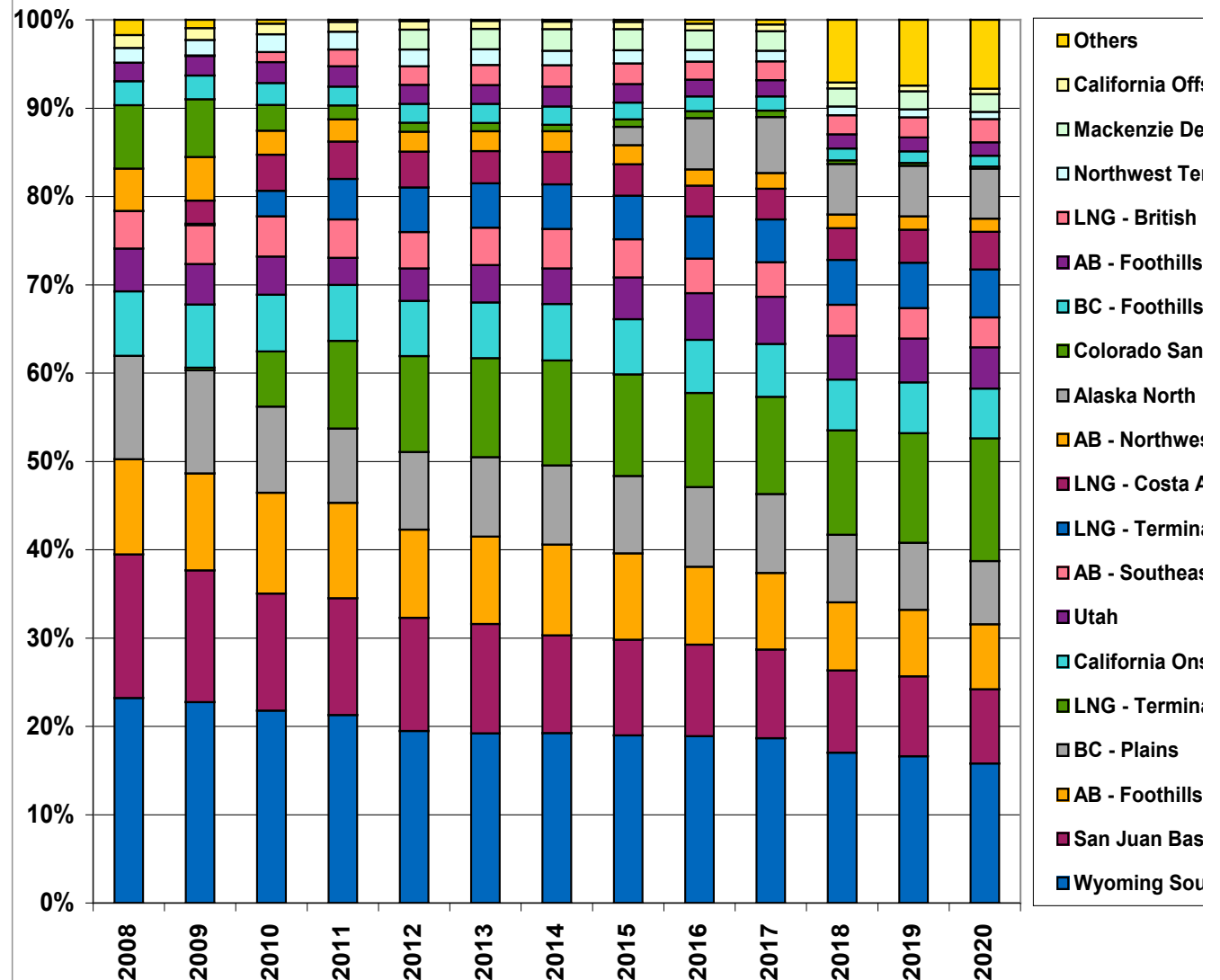


'Pacific' Demand Distribution by Producing Basins.

Here is an example of a census region and the producing basins that supply it.

Total Natural Gas Demand in 'Pacific' subregion is approximately 7,700 mmcf/d in 2010 and grows to approximately 9,160 mmcf/d by 2,020

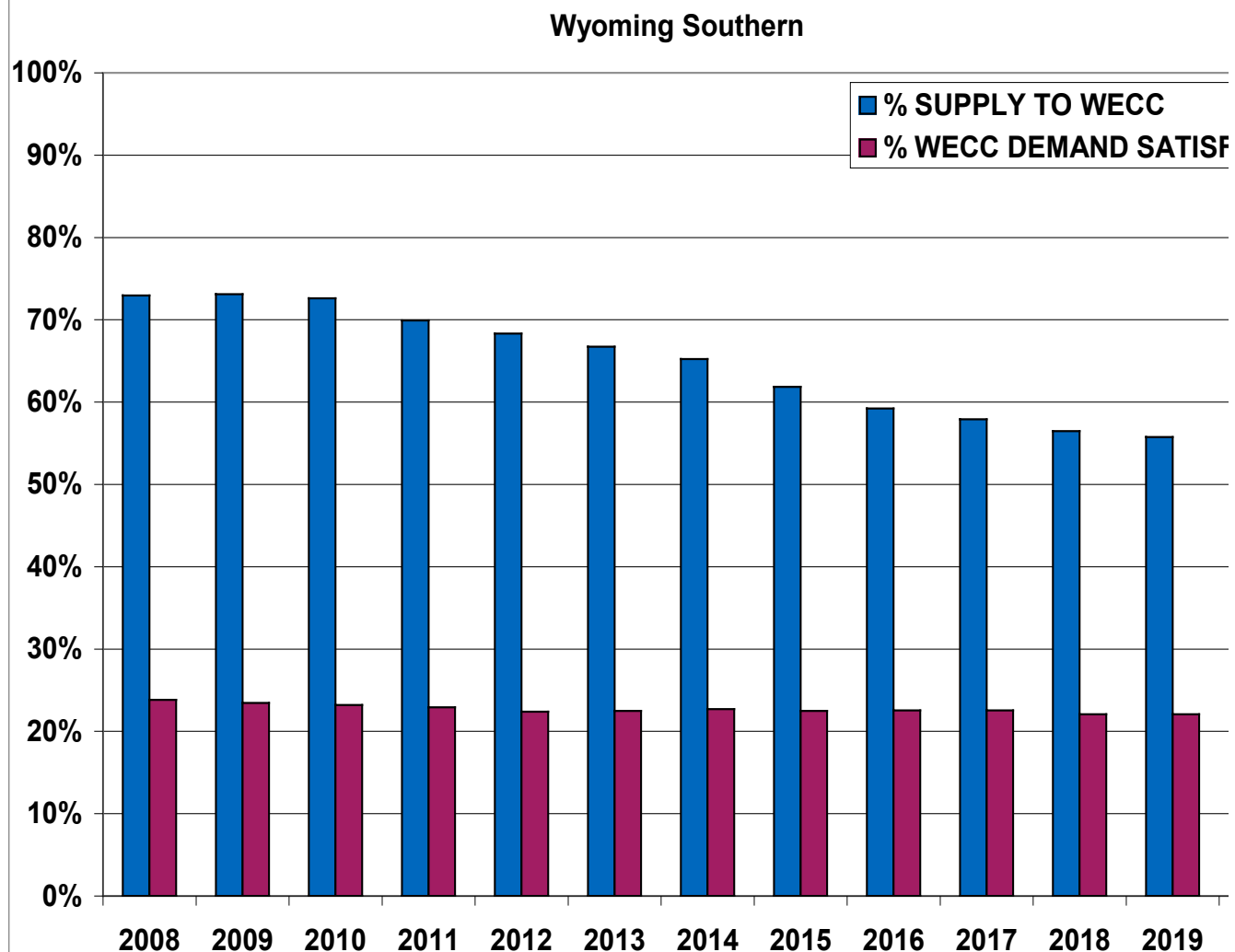
12 Producing Basins Supply 90% of Demand



The census regions cannot directly be aggregated by Reliability Council. WECC is approximately equal to Pacific and Mountain census regions. Here is an example of a producing basin and its supply to WECC.

In 2010, Wyoming Southern supply to WECC is expected to be approximately 2,700 mmcf/d representing approximately 70% of 3,750 mmcf/d of basin production. This supply will increase to approximately 3,200 mmcf/d in 2020, representing approximately 55% of 5,750 mmcf/d of basin production.

% Wyoming Southern Supply to WECC & % WECC Demand



Unlike the early hopes of the 1990's gas consuming industry, imported LNG will not "flood our market" with excess LNG and thus set a price ceiling.

We now conclude that such a flood of LNG will not occur because of international competition for such supply and the emergence of an LNG exporters cartel-like organization.

How is LNG Treated in GPCM®?

Each LNG import facility is treated as a supply source.

LNG is structured as an incremental supply for shortfall of indigenous production. LNG is a price taker with an infra-marginal price, i.e. slightly under the marginal indigenous price.

The LNG price includes

- A floor price set at recovery of marginal costs of regasified LNG from 23 plants and
- Winter prices that reflect international competition in Europe and Asia

GPCM® does not utilize a global LNG competition model i.e. LNG will flow as long as model needs LNG to satisfy NA demand to reach the equilibrium solution.

Integration of the GPCM® Outputs into the MarketSym® Cas for the IEPR Scenarios

The GPCM forecasts incorporated gas demand for the electricity sector from Market Analytics cases as shown below

For each GPCM gas forecast, Global Energy's Market Analytics team handed off the UEG gas demand to the Global Energy GPCM team.

For cases 3C and 5B-Plus, the resulting forecast was considered unusually significant. It was then handed back to Market Analytics to generate a separate Market Analytics case.

Market Analytics Case for IEPR Scenario	Description	GPCM gas forecast used in IEPR Case
1	Current conditions extended into the future	Base with P25 and P75 stochastic forecasts
1B	Compliance with current requirements	Base with P25 and P75 stochastic forecasts
2	High sustained natural gas and coal prices	Assumed \$10/MMBtu used to develop resource plan
3A	High energy efficiency in CA only	Base with P25 and P75 stochastic forecasts
3B	High energy efficiency throughout the West	Base with P25 and P75 stochastic forecasts
3C	High energy efficiency throughout West	3C
4A	High renewables in CA only	Base with P25 and P75 stochastic forecasts
4B	High renewables throughout the West	Base with P25 and P75 stochastic forecasts
5A	High energy efficiency and renewables in CA only	Base with P25 and P75 stochastic forecasts
5B	High energy efficiency and renewables throughout the West	Base with P25 and P75 stochastic forecasts
5B-Plus	High energy efficiency and renewables throughout the West and Lower Gas Prices Including production curtailment	5B-Plus

Market Analytics Integrates Data for Liquid Market Centers w GPCM Market Pricing Points

MARKETSYM LMC and Corresponding GPCM Market Pricing Points

	MARKETSYM LMC	GPCM MARKET POINT
1	AECO	AECO-C Hub
2	ANR SW	ANR - OK
3	Blanco	Blanco, NM
4	Broad Run	Broad Run/Cornwell, W V
5	Chicago	Chicago Hub
6	Dawn	DAWN, ONT.
7	Dracut	DRACUT (INTO TENNESSEE)
8	Florida Gate	FLORIDA GAS
9	Henry Hub	Henry Hub
10	Iroquois	IROQUOIS
11	Katy	KATY HUB TAILGATE
12	Kingsgate	Kingsgate
13	Kosciusko	Kosciusko, MS
14	Leach	Leach, KY
15	Lebanon	Lebanon, OH
16	Malin	Malin
17	Niagara	Niagara, NY
18	NY City	TRANSCO Z6 (NY)
19	Opal	Opal, W Y
20	Stanfield	Stanfield, OR
21	Sumas	SUMAS
22	Topock	Topock, AZ
23	Ventura	Ventura, IA
24	Waha	Waha Permian Basin Hub

SOURCE: Global Energy Decisions, Inc.

Global Energy's Appendix H-1 to the "Scenario Analyses of California's Electricity System: Preliminary Results for the 2007 IEPR" describes the integration of Market Analytics and GPCM, including how LNG is modeled, how volume and price are interrelated in GPCM, and how Global Energy's power, gas, coal, and emissions price forecasts are integrated.

Global Energy Liquid Market Centers and Related Burner-Tip Natural Gas Fuels

The map illustrates the natural gas pipeline network across the United States, categorized by regional market centers (LMC) and pipeline systems. The legend identifies the following regions and their corresponding colors:

- WECC** (Western Energy Center): Red
- MAPP** (Mid-America Pipeline): Green
- SPP** (Southwest Pipeline): Pink
- ERCOT** (Electric Reliability Council of Texas): Cyan
- MAIN** (Mid-America Natural Gas): Light Blue
- NPCC** (Northeast Pipeline): Grey
- FRCC** (Florida Regional Center): Yellow

Key pipeline hubs and regional market centers (LMC) are marked with circles and squares, respectively. The map shows a dense network of pipelines connecting these hubs across the country, with major hubs like AECO, Sumas, Kingsgate, and various regional centers like Chicago, New York City, and Houston. The legend also includes symbols for "Bumer" and "Tip Fuel" within dashed boxes.

SOURCE: Global Energy Decisions, Inc.

Methodology and Results of the Forecasts

We will focus on the Base, Scarcity and 5B-Plus forecasts.

We will compare the demand components of the inputs for these cases because demand is of special concern in this study.

We produced 8 separate gas forecasts

- Base
 - P25 Low Stochastic Forecast
 - P50 High Stochastic Forecast
- Sustained Scarcity
- 3B (High Energy Efficiency in the West)
- 3C (High Energy Efficiency in Western States/Provinces committed to Greenhouse Gas MOU)
- 5B (High Energy Efficiency and Renewables in the West)
- 5B-Plus (Same as 5B but with production curtailment response to low gas demand and decreased prices)

Developing the Base Case: Inherent Uncertainties

Natural gas forecasts based on any model are a “work in progress” with inherent uncertainties.

Optimum approaches to this inherent uncertainty incorporate scenarios, stochastic analysis, and frequent updates.

Studies into the impact of the growing activities of speculators are worth reviewing to evaluate price impacts.

We now describe how we developed the Base Case for this project. Let's remind ourselves of the inherent uncertainties.

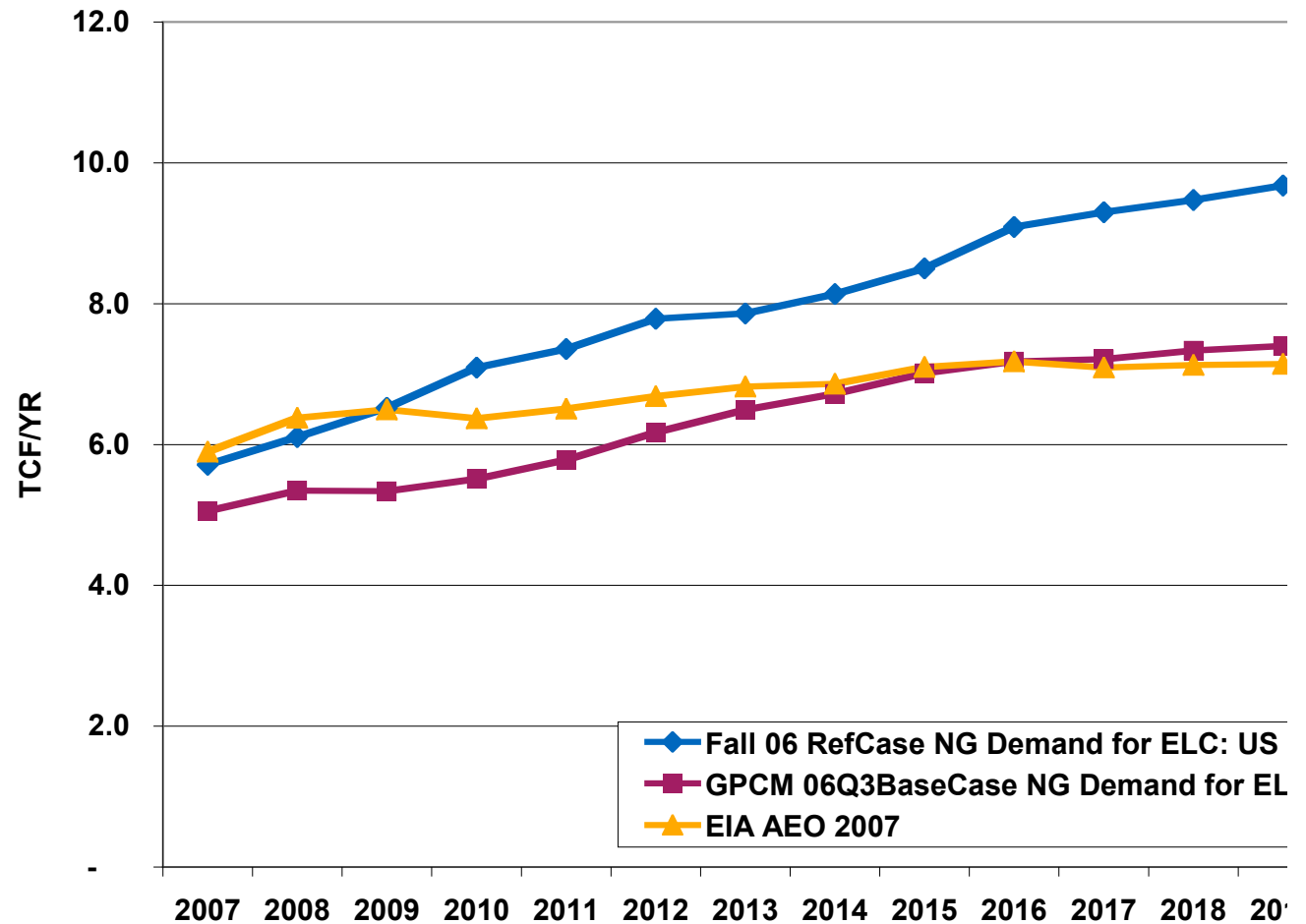
Key components of the North American gas system are complex and constantly changing, so that uncertainties in simulating them are inescapable

- Producing basins reflect changes in technology and market economics
- LNG import facilities experience uncertain permitting and assurance of liquefaction sources
- Mobilization infrastructure (pipelines, storage fields) must respond to constantly changing economic forces
- Market hubs for gas sales and purchases reflect the full spectrum of uncertainties in demand and supply
- Competing fuel prices such as crude oil have varying influences on gas prices and gyrate with geopolitical events
- Consumption is subject to constant reestimation as economic conditions change
- Non-commercial traders of gas futures and derivatives (“speculators”) may increase volatility or liquidity depending upon market conditions; their growing influence is hard to quantify.

How Gas Demand for Electricity Generation Differs in Our Base Case versus GPCM® and EIA's AEO 2007

Our gas Base Case (December, 2006) uses the demand assumptions from our Fall 2006 Market Analytics power Base Case. We show gas demand for electricity generation higher than do either GPCM 06 Third Quarter or EIA AEO 2007.

For the core load and for industrial gas demand, the Base Case has very similar demand assumptions as GPCM and EIA.

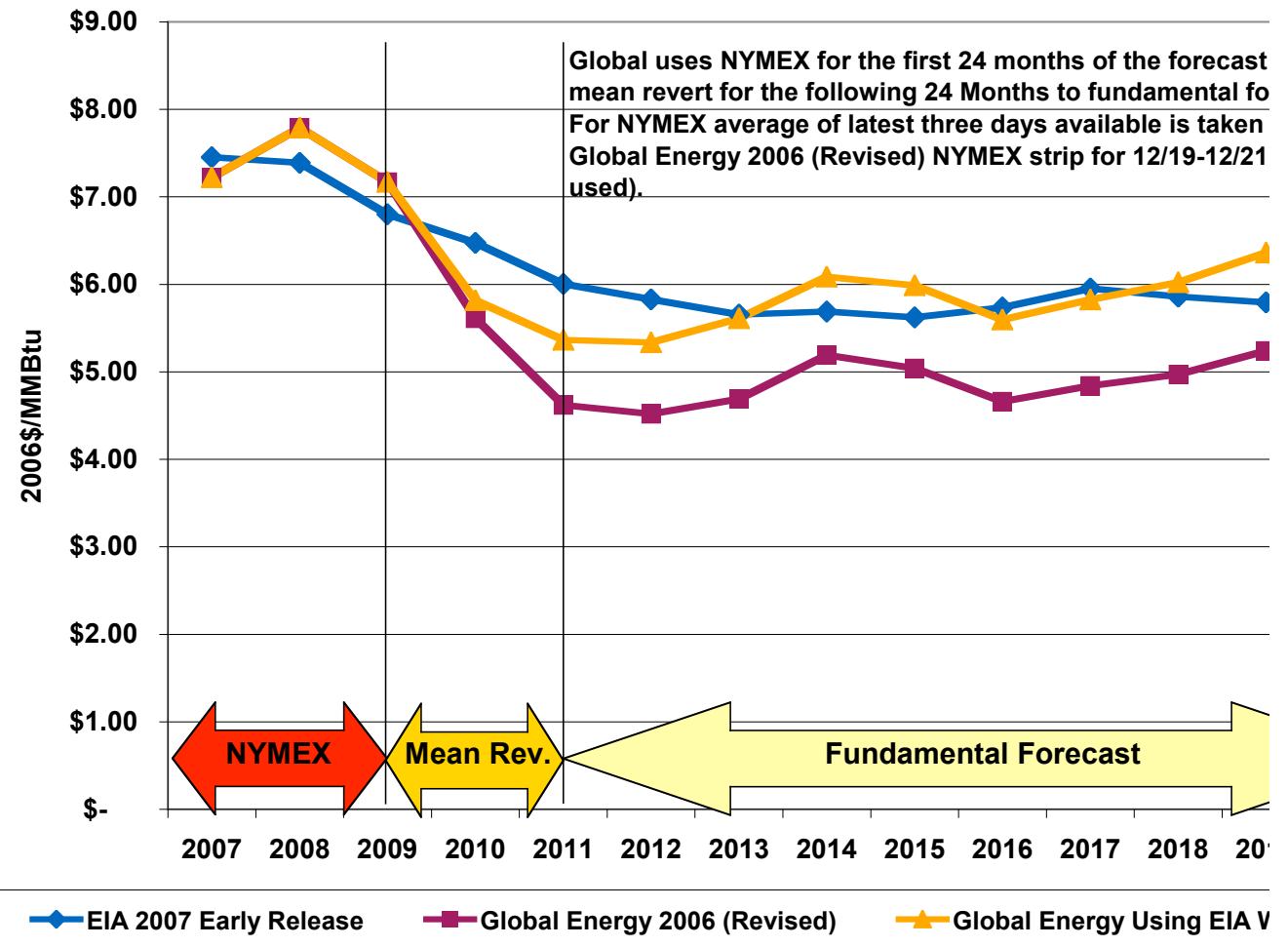


How Global Energy Incorporates the Influence of the NYMEX Futures Market in the First Two Years of the HH Forecast

Global Energy concludes that after 24 months, the liquidity in the futures market is such that it no longer provides good data on current Henry Hub gas prices.

Our mean reversion formulae for the subsequent 24 months reflect our historical volatility analyses.

After 48 months, the fundamental forecast is fully incorporated for the remainder of the long-term forecast period.

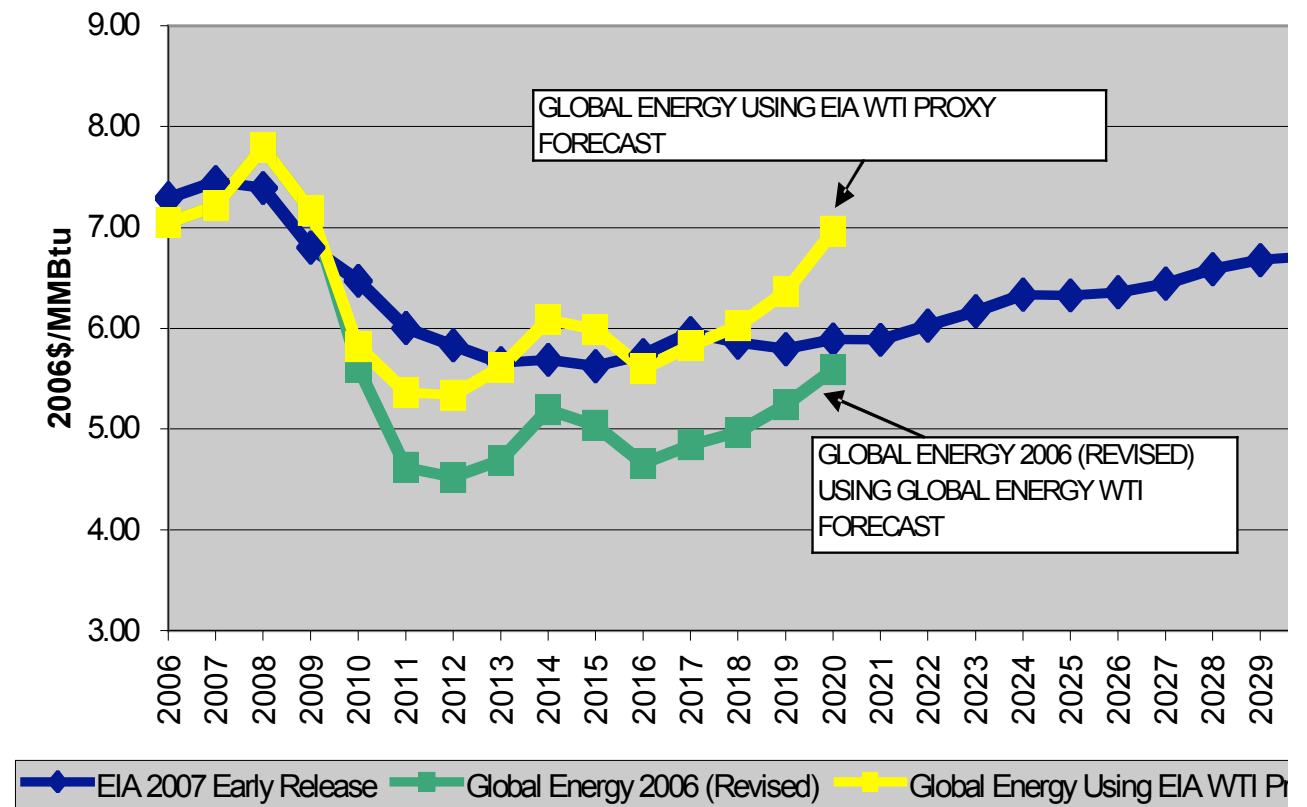


The Base Case (“Illustrative Base Case”) Henry Hub Natural Gas Price Projections Compared to EIA AEO 2007 Early Release and Global Energy 2006

Report Appendix H-2 describes the development of the Base Case (yellow line here).

It also compares the Base Case to EIA’s 2006 and 2007 gas forecasts, to clarify the methodological differences and similarities.

Global Energy’s HH forecasts all incorporate NYMEX futures for the first 24 months of the forecast as seen on the yellow line here.



Comparison of Oil Price, Demand Data, and LNG Supply Assumptions

Let's compare three features of the Base Case with EIA's 2007 Forecast:

The Base Case has the same crude oil forecast as does EIA 2007.

The Base Case projects somewhat higher U.S. gas consumption by 2020 than EIA 2007.

EIA's projects LNG imports considerably below the Base Case in part because EIA projects higher volumes of indigenous North American gas.

Crude Oil Price (\$2006/Bbl)

	EIA 2007	Base Case
2010	59.23	59.23
2015	51.40	51.40
2020	53.64	53.64

Gas Consumption (Tcf)

	EIA 2007	Base Case
2010	24.02	23.63
2015	25.32	25.77
2020	26.26	28.13

LNG Supply (Tcf)

	EIA 2007	Base Case
2010	1.81	3.81
2015	2.99	5.09
2020	3.69	6.89

GPCM forecasts basis differentials to market hubs throughout North America.

Basis differentials measure the value of gas at market points away from Henry Hub. Key factors include pipeline capacity and tariff cost, distance from and access to high value markets, and surplus or scarcity of productive capacity.

Time did not permit a full study of the data developed on this topic.

What Does our GPCM Base Forecast Tell Us About Basis Differentials to California? (2006\$/MMBtu)

		Basis Differential		Regional Gas Mkt Price	
	IBC HH	Malin	Topock	Malin	Topock
2007	7.22	-0.55	-0.55	6.67	6.66
2008	7.79	-0.51	-0.58	7.28	7.21
2009	7.32	-0.25	-0.27	7.07	7.06
2010	6.12	-0.27	-0.25	5.85	5.87
2011	5.36	0.01	-0.04	5.38	5.32
2012	5.34	-0.01	-0.03	5.33	5.30
2013	5.61	0.01	0.01	5.62	5.62
2014	6.09	0.03	0.00	6.12	6.08
2015	5.99	-0.03	-0.02	5.96	5.97
2016	5.60	-0.13	-0.06	5.46	5.53
2017	5.83	-0.14	-0.05	5.69	5.78
2018	6.02	-0.16	-0.06	5.86	5.96
2019	6.36	-0.15	-0.04	6.21	6.32
2020	6.96	-0.16	-0.04	6.80	6.92

2007-2010 Based on NYMEX Forecast (average of three days of settlement prices – Dec 19, 20, 21 of 2006) for 2007 and 2008

2011-2020 Total GPCM Forecast (supply demand fundamentals)

Some Major Changes in Global Energy Natural Gas Base Cases 2006-2007

Global Energy's Fall 2007 gas Ref Case will feature more natural gas demand for ethanol production and Canadian Tar Sands.

It will have a new crude oil forecast

It will further delay ANS to 2020 and MacKenzie Delta to 2018.

Electricity demand will come from GED Spring 07 Power Ref Case

Fall 2006

- Electricity demand from GED Spring 06 Power Ref Case
- Other demand from GED econometric models Fall 06
- Crude oil (WTI) forecast GED Fall 06

December 2006

- Electricity demand from GED Fall 06 Power Ref Case

CEC Base Case

- GED December 2006 Ref Case with EIA's 2007 WTI Proxy crude oil forecast

Spring 2007

- New GED crude oil forecast
- Less LNG due to global price competition
- Green premium – global push for cleaner fuels
- Delayed Alaska North Slope gas from 2016 to 2018 and Mackenzie Delta from 2010 to 2014

Crude Oil Forecast and Oil/Gas Ratios Used in the Base Cas

Crude oil forecast is an important input to GPCM.

Crude oil to natural gas ratio is also a key input.

	EIA AEO 2007 Early Release WTI-Proxy ⁽¹⁾ GED Modified ⁽²⁾	EIA AEO 2007 (Early Release) WTI Proxy <i>Divided by:</i> Henry Hub
	2006\$/Bbl	MMBtu/Bbl
2007	68.75	9.23
2008	66.06	8.94
2009	62.77	9.23
2010	59.23	9.15
2011	56.00	9.33
2012	53.30	9.14
2013	51.52	9.11
2014	51.16	8.99
2015	51.40	9.14
2016	51.27	8.94
2017	52.35	8.79
2018	52.85	9.02
2019	53.54	9.24
2020	53.64	9.11

- 1) EIA WTI-Proxy is its Imported Low-Sulfur Light Crude Oil price proje
- 2) Converted from 2005\$ to 2006\$
- 3) On right hand column, ratio uses Base Case gas forecast

Sustained Scarcity Forecast

Characteristics

Delays this year in bringing Arctic gas to the Lower 48 and sustained high oil prices have brought increased importance to this case.

Alternative forecasts such as this one are an essential element in defining the range of fuel price uncertainty.

- Indigenous U.S. production drops sharply (35% decline in comparison to Base Case, by 2020)
- No Arctic North Slope or Mackenzie Delta gas until 2020
- High oil prices very high (\$75-\$85)
- High utilization rates for LNG facilities

Results (2006\$/MMBtu)

	Scarcity	Base Case
2010	8.78	5.82
2015	10.13	5.99
2020	10.55	6.96

GPCM does not include an automatic loop-back that would curtail production in response to lower demand, but it includes the capability to do so manually, as we describe for Forecast 5B Plus.

Low Demand Forecasts

We now describe our investigation of the impacts on natural gas Henry Hub prices of gas demand lowered due to increased use of Energy Efficiency (EE) and Renewables as substitutes for gas-fired power generation.

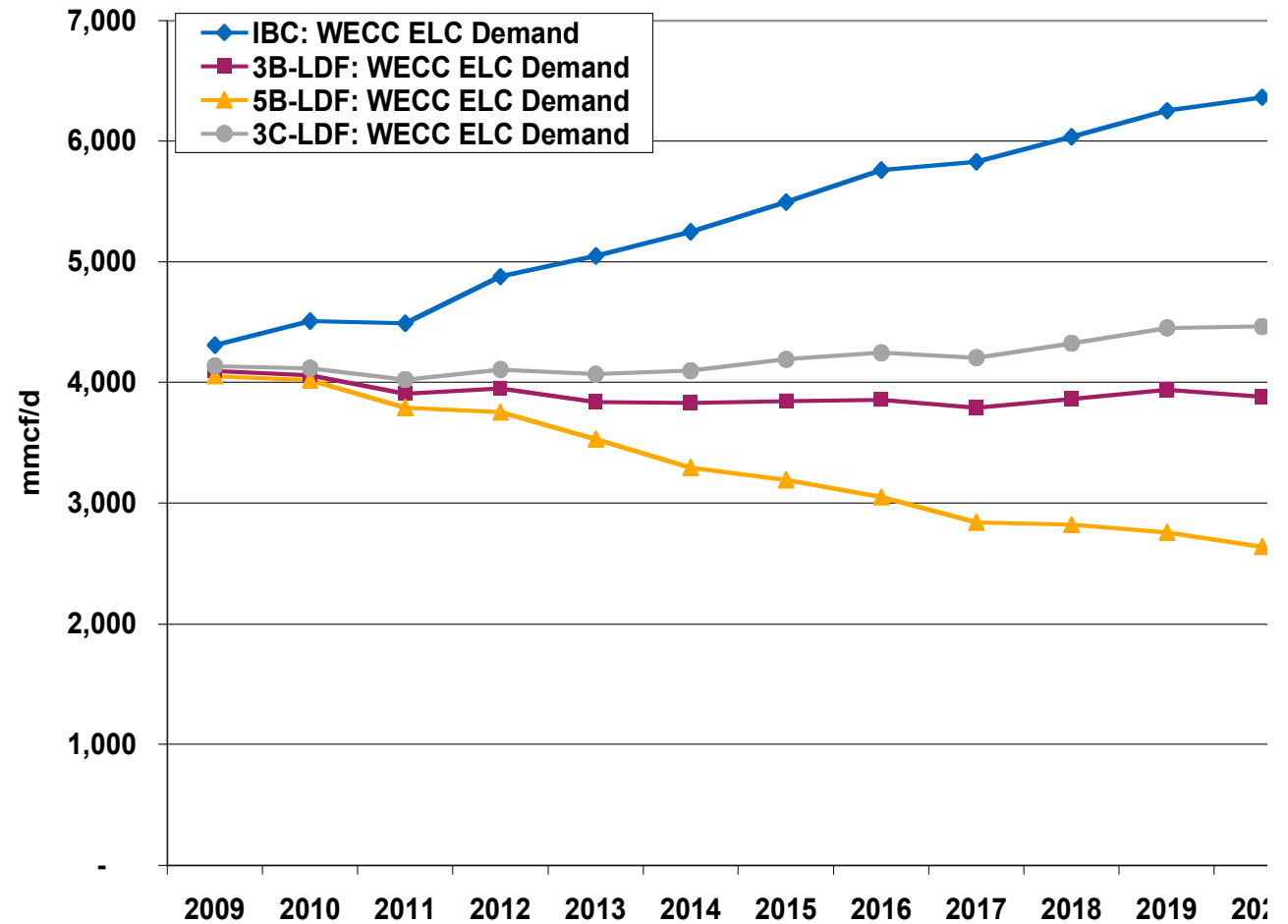
- 3B
- 3C
- 5B
- 5B-Plus

3B, 3C, and 5B were incomplete in an important respect: they did not include any modeling of the response of the production industry to limit new production (“supply bubble”) when demand drops in a sustained way.

5B-Plus fills in this final piece to the puzzle.

Low Demand Forecasts

IBC, 3B-LDF, 3C-LDF, and 5B-LDF: WECC Natural Gas Demand For Electric Gen



3B-high EE throughout WECC

3C-high EE in CA, NM, AZ, OR, WA, BC

5B – high EE and renewables throughout WECC

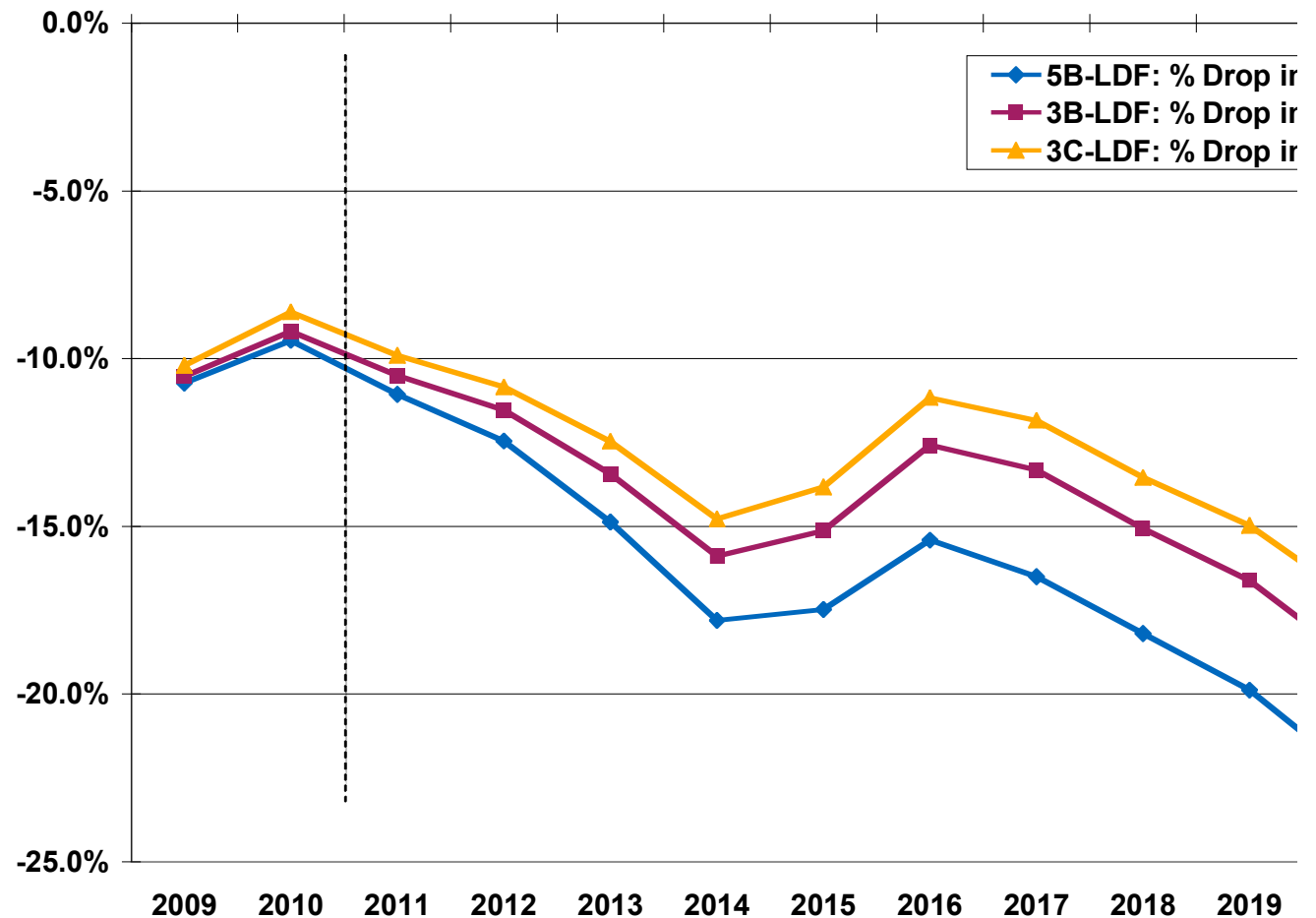
These cases did not include modeling a production curtailment response from the gas industry.

These forecasts clearly demonstrated that lowered demand impacted gas prices.

To better quantify this drop, we wanted to correct an important flaw: to model a realistic production capacity response to lowered price.

During the “gas bubble” of the late 1980’s and 1990’s, such a response occurred.

3B-LDF, 3C-LDF, and 5B-LDF: Percentage Drop In Henry Hub (2006\$)(1) From IBC



- 1) For Henry Hub forecast GED uses NYMEX for the first 24 months and then mean revenue following 24 months to our fundamental forecast. For IBC forecast starting in 2007 for NYMEX an average of the latest available three days were used (i.e. Dec 19-21 2006).

Report Appendix H-5 describes the methodology for simulating the production curtailment response.

We presented and compared various approaches. We explained how the “upstream” portion of GPCM works and how it could be used to simulate production curtailment.

Low Demand Forecast 5B-Plus Simulates a Production Curtailment Response

Characteristics

WECC-regional, focusing on production basins most important in supplying WECC

We modeled the response according to observable exploration/production industry behavior

- Some production is not curtailed because associated with oil production
- Another tranche is unconventional gas resource that cannot be curtailed without permanent reservoir damage
- Another tranche is not curtailed because small to mid-sized independents must produce to service debt and avoid competitive drainage
- Supply curtailment is lagged by three years to account for delayed industry response to price decreases

Results in Volume (MMcf/d and %) of the 5B-Plus Forecast, Showing the Supply Curtailment.
Demand Volumes in WECC are Reduced Compared to the IBC and 5B

	IBC: WECC TOTAL NG Demand	5B-LDF: WECC TOTAL NG Demand	Demand Drop in WECC	% Drop in TOTAL WECC Demand	IBC Gross Production*	IBC Net Production to WECC*	5B Plus Gross Production*	5B Plus Net Production to WECC*	Supply Curtailment to WECC*	Lagged Supply Curtailment	% TC WI Su To De
mmcf/d											
	A	B	C	D	E	F	G	H	I	J	
				C / A					H - F		
2009	11,402	11,146	(256)	-2%	9,397	7,260	9,397	7,260			
2010	11,715	11,223	(492)	-4%	9,360	6,970	9,360	6,970			
2011	11,806	11,105	(701)	-6%	9,447	6,817	9,447	6,817			
2012	12,294	11,169	(1,125)	-9%	9,609	6,892	8,960	6,191	(701)	-7%	
2013	12,553	11,034	(1,519)	-12%	9,835	7,011	8,892	6,119	(892)	-8%	
2014	12,823	10,870	(1,953)	-15%	10,090	7,087	8,985	6,023	(1,064)	-10%	
2015	13,145	10,842	(2,303)	-18%	10,482	7,214	9,185	5,826	(1,388)	-11%	
2016	13,486	10,775	(2,711)	-20%	10,960	7,397	9,450	5,576	(1,821)	-12%	
2017	13,626	10,638	(2,988)	-22%	11,106	7,399	9,427	5,371	(2,027)	-14%	
2018	13,906	10,690	(3,216)	-23%	11,170	7,239	9,320	5,185	(2,054)	-15%	
2019	14,207	10,712	(3,495)	-25%	11,387	7,315	9,349	5,095	(2,220)	-16%	
2020	14,417	10,692	(3,725)	-26%	11,466	7,268	9,279	4,857	(2,411)	-17%	

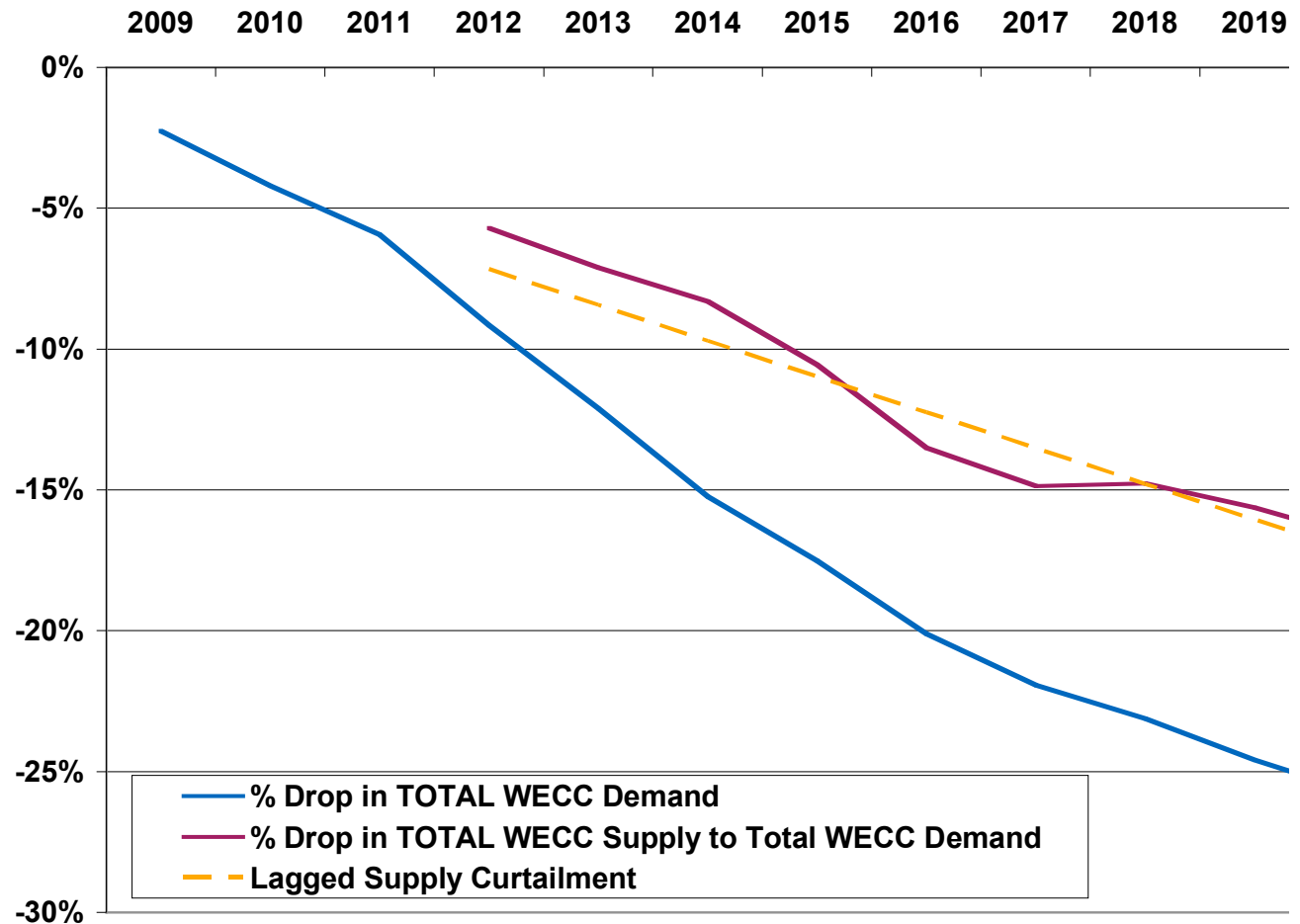
*California Onshore, Colorado Northeast, Colorado San Juan, San Juan (NM), Utah, Wyoming Southern

For 5B-Plus, we modeled production curtailment in California Onshore, Colorado Northeast, Colorado San Juan, San Juan (New Mexico), Utah, and Wyoming Southern.

By 2020 there was a 17% drop in Total WECC supply to Total WECC demand.

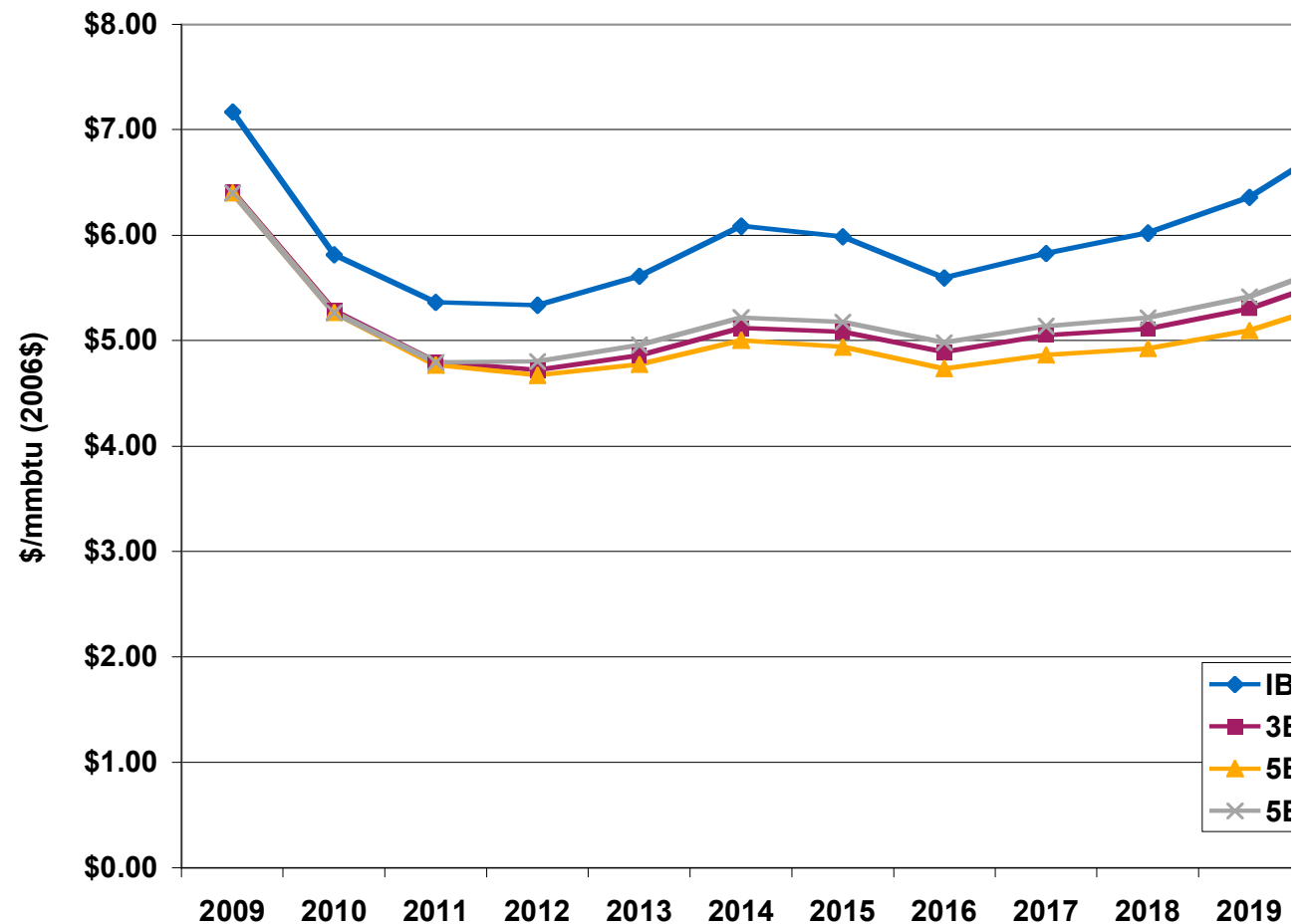
We modeled the demand drop beginning in 2009 while the supply curtailment is lagged three years, beginning in 2012.

Results of Forecast 5BPlus, Showing the Drop in WECC Demand and the Resulting Supply Curtailment



This case demonstrates the impact of lowered demand from aggressive use of EE and renewables even when the industry responds with production curtailment.

Results of 5B-Plus (Production Curtailment Response) IBC, 3B, 5B, and 5B-Plus: Henry Hub (2006\$)⁽¹⁾



- 1) For Henry Hub forecast GED uses NYMEX for the first 24 months and then mean reverts for following 24 months to our fundamental forecast. For IBC forecast starting in 2007 for NYMEX an average of the latest available three days were used (i.e. 19-21 2006).

Average Henry Hub Prices Forecast 2011-2020 for Base Case, 3B, 5B, and 5B-Plus (2006\$/MMBtu)

According to this modeling exercise, the production curtailment response to adjust to lower demand will lessen the price decrease (versus the Base Case) from roughly -\$1.00 (in 5B) to roughly -\$0.77 (5B-Plus).

Average	IBC	3B	5B	5B Plus
2011-2020 (2006\$/MMBtu)	5.92	5.06	4.92	5.15
Decrease vs. IBC (2006\$/MMBtu)		0.86	1.00	0.77
Decrease vs. IBC %		-17%	-20%	-15%

Forecast 5B-Plus, and the forecasts leading up to it, provide a credible foundation on which to continue the quantification of the impact and benefits of replacing gas-fired power with energy efficiency and renewable energy.

The benefits of lowered gas prices in response to high EE and renewables have been addressed in a 2005 study by Lawrence Berkeley Laboratories. We have not yet compared our study with the LBL study to see how they may complement or supplement each other.

Limitations of This Analysis

This process has provided a disciplined step-by-step analysis with the evaluation of results at each juncture.

But this analysis has limitations that prevent our relying upon the specific results.

During the time in which the analysis was performed (December, 2006 through June, 2007) important changes occurred in all of the inputs to GPCM and Global Energy's Reference Case

- GPCM has been updated twice
- Global Energy Reference Case updated once

An example is the delay in new pipelines to bring Arctic gas to the Canadian and U.S. market areas

The crude oil to natural gas price ratio has increased dramatically and stayed high

New infrastructure has been announced or cancelled

Our study of natural gas price trends under conditions of lowered demand and supply scarcity has provided some important answers.

Nonetheless, the results pose many important questions still to be answered.

.

Logical Follow-Up Work

Review LBL research on the benefits of lowered natural gas prices in response to lowered demand for gas-fired power through substitution of EE and renewables. How do the studies complement or supplement each other and are their conclusions mutually consistent?

Analyze the impacts of the lowered demand in the various cases on basis differentials throughout WECC.

Analyze the information on needed infrastructure (new pipelines, expansions of existing pipelines, storage fields) that was generated as the result of the six GPCM scenario forecasts.

Investigate the “what if’s” of the Canadian production industry ability (or inability) to supply U.S. and WECC incremental future demand. What if some renewables and EE are also delayed?

Identify the need LNG import facilities in WECC: when, where, and how much?

Ask what would happen to gas prices if supply scarcity and extreme conditions such as drought or nuclear outages were to co-occur?

Some Introductory Information About Global Energy Decisions

The following slides provide introductory information about Global Energy Decisions

Global Energy is a credible advisor on such topics as electricity scenario analysis and natural gas forecasts because we provide independent and integrated analytics to all leading segments of the energy industry

Global Energy's Gas Price Analytics Team

George Given, Vice President-Global Energy Advisors:

Heads Global Energy's Market and Fuels Advisory Services (Power, Gas, Oil, and Coal). Mr. Given is responsible for delivery of the forecasting products and maintaining consistency and integration of the fuel and emission forecasts within the energy modeling platform used by Global Energy. He directs projects in power market analysis, regional energy price forecasting, fuel price forecasting, emission price forecasting, asset management, divestment, and risk. He has extensive experience in the energy industry including the upstream petroleum sector, energy research and power and fuels consulting. Prior to joining Global Energy he was a Senior Economist with the Canadian Energy Research Institute (CERI). B.A. (Honors), M.A., Economics, University of Calgary.

Dr. Michael Donnelly, Ph.D. Vice President, Strategic Consulting

The practice leader for strategic fuel consulting and fuel market analytics. Has over 35 years of experience in the energy industry in North and South America and the Middle East; 25 years of experience in fuel commodities including exploration, development, processing, transportation, and marketing. An authority on the evaluation and development of fossil fuel reserves. During 15 years of advisory consulting he has focused on the upstream conversion of energy fuels into electrical power, on infrastructure capacity for power generation and transmission, reservoir performance and reserve evaluation, and power market analysis. Recently, has focused on LNG and Arctic gas, representing some of the leading suppliers in the developing world gas market. Ph.D., Geology, Stanford University.

Global Energy's Gas Price Analytics Team

Dr. Ann Donnelly, Ph.D. Director, Strategic Consulting:

Leads advisory consulting engagements. 35+ years of experience in the exploration for and development, transportation, marketing, and contracting of gas, oil, coalbed methane, nuclear fuels, and in the applications of fuels to the electric power industry. She is an authority on the evaluation of fossil fuel reserves. Engagements have included fuel planning and contracts for power generation throughout North America, fuel procurement for large manufacturers, assessments of hydrocarbon reserve acquisitions, negotiations of special utility tariffs for both electricity and natural gas service, development of customer aggregation groups, and a variety of expert witness cases. B.Sc. Geology, Stanford University; Ph.D., Geology University of California, Santa Barbara.

Gurinder Goel, Senior Consultant, Global Energy Fuels:

Is an expert in oil and gas market analysis. His areas of specialization include deepwater project economics and project feasibility analysis; financial modeling and energy portfolio analysis; gas fundamental modeling and energy project strategy analysis. Before joining Global Energy he was a financial and strategy analyst for PFC Energy. Previously he served as an analyst for Abt Associates. He has a Master of International Economics degree from Radford University and an MBA from University of Mumbai.

Global Energy's Gas Price Analytics Team

Lou Barton, Project Manager, Global Energy Advisors:

Has over 30 years of experience in the energy industry. As Project Manager on the fuels team, he is an expert analyst of electric generation costs and fuels planning, acquisition, logistics for commodities such as natural gas, coal, LNG, coal, and air emissions allowances, as well as state/federal regulatory affairs. His work has involved natural gas acquisition strategies for deregulated independent and municipal electric generators and cogeneration units, regional gas and long-term energy price forecasting, fuel and air emissions markets, pipeline rates and tariffs, gas/electric trading, and electric market clearing prices for electric generation clients and interstate pipeline companies performing creditworthiness analysis. B.A., Mathematics, University of Bridgeport; M.B.A., Finance, University of Connecticut.

Andrew Wetz, Project Manager, Global Energy Fuels:

Directs economic analysis for Global Energy's advisory consulting projects involving all the energy fuels as well as the electricity and renewables markets; has over 25 years experience in financial and economic analysis of energy development from the wellhead to the burnertip/busbar and for a wide variety of energy users and providers in North and South America and the Middle East. He draws upon his extensive experience analyzing the economic and financial performance of energy projects to perform economic modeling and planning in support of transactional due diligence, contract negotiations, portfolio assessment, energy procurements and risk analysis. B.S. in Mathematics, MBA, Finance, University of Texas, Austin.

OVERVIEW

400+ client relationships include at many of the industry's leading global market participants



Global Energy Decisions: In Summary

The world's leading asset-centric energy companies rely on our solutions to:

- Forecast electric pricing and demand
- Conduct resource planning
- Manage risk
- Trade energy and schedule delivery
- Value assets
- Optimize generation performance
- Understand and manage their financial position

Product lines

- **EnerPrise** – Enterprise class software applications
- **Velocity Suite** – Historic energy markets data & tools
- **Advisors** – Advisory services and applications consulting

Company formed October 2002 with the acquisition of Henwood Energy

- Subsequent to Henwood acquisition, Global Energy made four material acquisitions/investments: Energy Velocity, M.S. Gerber and ABB Wholesale software unit, KW International Ltd., today operating under one brand

Over 280 talented experts to provide integrated data, software and analytics

Domain expertise in world-wide energy markets

Using footprint to expand support hours

Who We Are Today: Global Company

- **Client Relationship Management:** In each geographic market
- **Software Development Centers:** Sacramento, London, Raleigh
- **Consulting Bases:** Sacramento, Portland, Houston, Kansas City, London, Brisbane
- **Data Operations:** Boulder, Sacramento, London

